SOIL COMPACTION OF PEAT UNDER THE INFLUENCE OF ELECTROKINETIC STABILIZATION (EKS) TREATMENT

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DEDICATION

Dedicated to my beloved grandparents, parents, siblings, wife, kids and sweet friends.

Mr. Abdul Hadi

Shaheed Sajad Anjum

Roshni Wahab

Adil Wahab

For their love, endless support, patient, encouragement & sacrifices.

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ABSTRACT

This study aims to enhance the properties of peat such as, (shear strength, compressibility, permeability and liquid limit). Peat is considered as one of the problematic soil in construction projects all over the world, which covers about 4% land of the whole world while 8% of the total area of Malaysia and about (5.86%) of peat soil existing in Johor state. Low shear strength of peat may lead to massive loss of various sectors contributing toward any economic activities such as construction & agriculture projects. There are several issues related to peat stabilization which has become a priority to ensure that soft soil is stable & capable of supporting a load after treated by a suitable soil stabilization method. The problem can be finally reduced by applying stabilization treatment to enhance its properties. One of the known technique Electrokinetic Stabilization treatment, by applying an electric potential to stabilize soft soil. In this method, aluminum was used as an electrode with various voltage potential in the range of 110 to 150 V was applied on both cathode and anode electrode for the duration of 3 and 6 hours at the testing condition without & with a load of (50 kg). Soil parameters such as, shear strength (τ), moisture content (MC), liquid limit (LL), bulk density (ρ), maximum dry density & dynamic properties have been studied for each combination of voltage and operational time of this EKS treatment There were twenty peat sampling sites at Parit Botak area, Batu Pahat, Johor Darul Takzim, was investigated in this study but the soil samples were collected from three various locations which is Parit Haji Ali (PHA), Parit Nipah (PN) and Parit Lapis Kadir (PLK). The peat soil was further treated based on the change of the shear strength magnitude. Results have shown that, shear strength for PHA peat was improved up to (84%) & MC was decreased (54%), while for shear strength for PN peat was improved up to (68%) & MC (56%). Similarly, the shear strength for PLK peat was improved up to (59%) & MC was decreased (64%). From the experimental results, it stated, that EKS treatment is capable to improve the physical properties peat effectively.

ABSTRAK

Tujuan kajian ini adalah untuk meningkatkan sifat fizikal tanah gambut seperti kekuatan ricih, kebolehmampatan, kebolehtelapan dan had konsisten. Tanah gambut dianggap sebagai salah satu daripada tanah yang bermasalah dalam pembinaan dan ianya meliputi kira-kira 8% daripada jumlah tanah di Malaysia. Sifat fizilal kekuatan gambut yang rendah boleh mengakibatkan kerugian besar terhadap sektor yang menyumbang kepada aktiviti ekonomi seperti projek pembinaan. Untuk mengatasi masalah ini, beberapa isu berkaitan dengan sifat kekuatan tanah gambut yang lembut ini perlu diatasi. Di sini, penyiasatan terhadap pemadatan tanah gambut menjadi keutamaan bagi memastikan tanah lembut ini stabil dan mampu untuk menyokong beban selepas dirawat dengan teknik penstabilan tanah yang bersesuaian. Ini dilakukan dengan kaedah rawatan penstabilan tanah untuk meningkatkan sifat fizikalnya. Salah satu teknik yang digunakan adalah dengan menggenakan bezaupaya bagi penstabilan tanah ini. Dalam kaedah ini, aluminium digunakan sebagai elektrod. Bezaupaya yang digunakan adalah dari julat 110 V hingga 150 V, dikenakan kepada kedua-dua katod dan anod untuk tempoh operasi selama 3 jam dan 6 jam, pada keadaan pengujian kekuatan tanpa beban dan dengan beban (50 kg). Antara parameter tanah yang terlibat adalah seperti kekuatan ricih, (τ), kandungan lembapan (W_N), had cecair (W_L), ketumpatan pukal (ρ), ketumpatan kering maksimum dan sifat dinamik telah dikaji untuk setiap gabungan parameter voltan dan tempoh masa pengoperasian rawatan EKS ini. Terdapat dua puluh tapak persampelan tanah gambut di sekitar Parit Botak, Batu Pahat yang terlibat dalam kajian ini, tetapi hanya tiga sampel tanah gambut yang dirawat yang mana ianya merupakan tanah yang mempunyai kekuatan ricih terendah. Keputusan eksperimen menunjukkan bahawa kekuatan ricih untuk tanah gambut di lokasi Parit Haji Ali meningkat daripada (84%) dan kandungan lembapan berkurangan daripada (54%), manakala kekuatan ricih untuk tanah gambut di lokasi Parit Nipah pula meningkat daripada (59%) dan kandungan lembapannya berkurangan dari (64%). Keputusan yang sama bagi kekuatan ricih untuk tanah gambut di lokasi Parit Lapis

Kadir, di mana kekuatan ricihnya meningkat dari (59%) dan kandungan lembapan berkurangan daripada (64%). Dari hasil eksperimen, ia menunjukkan bahawa rawatan EKS mampu meningkatkan sifat fizikal tanah gambut dengan berkesan.

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LIST OF SYMBOLS AND ABBREVIATIONS

ρ_b	-	Bulk density
ρ_d	-	Dry bulk density
σ_n	-	Natural stress on slip surface
c	-	Apparent cohesion
G_{max}	-	Small strain shear modulus
M_{max}	-	Small strained constrained modulus
M_s	-	Mass of soil
^oC	-	Degrees Celsius
v	-	Velocity
V	-	Voltage
V_p	-	Primary wave velocity
V_s	-	Shear wave velocity
V_t	-	Internal volume of cutter (cm^3)
V_t	-	Volume of cylinder
W	-	Water content
W_L	-	Liquid limit
W_N	-	Moisture content
λ	-	Wavelength
μm	-	Micrometer
ϕ	-	Angle of friction
Δt	-	Travel time
v	-	Velocity
τ	-	Shear strength
BD	-	Bulk density
BS	-	British Standard
cm	-	Centimeter
d	-	Diameter of the vane

DC	-	Direct current
e.g.	-	For example (exempli gratia)
EK	-	Electrokinetic stabilization
GPS	-	Global Positioning System
H	-	Height of the vane
hr	-	Hectares
i.e.	-	For example
kg	-	Kilogram
kHz	-	kilohertz
km	-	Kilometer
kPa	-	Kilo pascal
LL	-	Liquid limit
M	-	Mass of wet soil in cutter (g)
MASW	-	Multi-channel Analysis of Surface Wave
MC	-	Moisture content
mh	-	Million hectare
MDD	-	Maximum dry density
mm	-	Millimeter
OMC	-	Optimum moisture content
PB	-	Parit Botak
PHA	-	Parit Haji Ali
P_L	-	Plastic limit
PLK	-	Parit Lapis Kadir
PN	-	Parit Nipah
RECESS		Research Centre for Soft Soil
SW	-	Shear wave
T	-	Maximum torque at failure
USA	-	United State of America
UTHM		Universiti Tun Hussein Onn Malaysia

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LIST OF PUBLICATIONS

i. **Wahab. A.,** Embong. Z., Naseem. A., Madun. A., Zainorabidin. A., Kumar. V., (2018) The Effect of Electrokinetic Stabilization (EKS) on Peat Soil Properties at Parit Botak area, Batu Pahat, Johor, Malaysia, in Indian Journal of Science and Technology **(ISI Indexed) (Published)**

ii. **Wahab. A.,** Embong. Z., Naseem. Idrus. M. M., Zainorabidin A., Norshuhaila. M. S., Saif ul Azhar. A. T, (2018) Peat Soil Improvement using Electrokinetic Stabilization (EKS) Treatment at Parit Lapis Kadir, Batu Pahat, Johor, Malaysia presented in *International Nuclear Science, Technology and Engineering Conference UTM, 2018)* **(Scopus Indexed) (Accepted)**

iii. **Wahab. A.,** Embong. Z., Naseem. A., (2018) Shear Strength Improvement of Peat Soil by Electrokinetic Stabilization Treatment (EKSR) at Peninsular *Malaysia in the International Journal of Engineering and Technology* **(Scopus Indexed) (Under Review)**

iv. **Wahab. A.,** Embong. Z., (2019) Physicochemical and Mechanical Properties Improvement of Peat Soil by Electrokinetic Stabilization Method at Parit Botak area, Johor Malaysia, *CHEMOSPHERE ELSEVIER*. **(ISI, Scopus Indexed: IF=4.42) (Under Review)**

CHAPTER 1

INTRODUCTION

1.1 Background of the study

The soil is mixture of different components and minerals deposits such as 45% minerals, 23 % water, 23% air and about 8% of organic materials and living matters as shown in Figure 1.1. Soil is considered to be the key part in all types of constructions and infrastructure projects all over the world. Soil have different types with various properties, some soil has very week properties like low strength and high compressibility features, i.e. peat soil. The soil strength is most significant and contributing towards several types of constructions and infrastructure such as buildings, roads, tunnels, dames and railways tracks constructions. It plays a vital role in the overall infrastructure of developed or developing countries. The soil conditions are subjected to be one of the critical factors in groundwork design. To start a foundation design, a soil scientist needs to get prior information from the proposed site. Furthermore, soil scientists must have adequate knowledge of the properties of soil. Meanwhile, the emerging countries lack a standardized procedure for the selection of soil particularly, for construction purposes. It is critically imperative to possess several parameters of the soil being used for construction under consideration. Being a developing country such as Malaysia also facing the same problem that requires an appropriate and substantially immediate attention to overcome the resulting loss caused by the selection of poor soil for construction purposes.

The identification of various locations which comprises of compressible soil which are feasible for construction and transportation projects. Which is extremely important that will significantly expand the quality of roads and buildings spread over

the entire territory of the country. Hence these facts are under consideration, the constructions on soft soil have become a big challenge for construction engineers all over the globe due to its poor properties (i.e. low shear strength, high compressibility and high-water-content). It creates difficulties during or after construction, e.g. (slope instability and bearing capacity failure or excessive settlement) (Hua *et al.*, 2016). Soil with poor properties such as peat, which is mostly present in earth's surface where the water table is nearby or above the ground level, but in some case peat soil is existing as deep deposits. The high moisture content of peat depends on rainfall and surface topography. High moisture content, high compressibility, low bearing capacity and low shear strength of peat are the central characterization. The properties as mentioned above are making peat unfeasible and unstable to bear excessive load (Sadon *et al.*, 2014).

Peat is found all over the world especially in tropical countries such as Russia, Canada, Indonesia and Malaysia. In Malaysia, there are about 3 million hectares of peat or approximately 8% of the whole land of the country covered by peat deposits. Sarawak state is the largest peatland with 1.66 million hectares, which comprised about 13% of the total area while 143,974 hectares (5.86%) of the peat exists in the coastal part of West Johor state (Batu Pahat, Pontian, and Muar district) (Melling, 2016).

Therefore, it's essential to enhance the properties of peat to make it feasible for any construction. There are many types of techniques to stabilized soft soil (e.g. mechanical stabilization, stabilization by using various admixtures like lime stabilization, cement stabilization, fly ash stabilization, thermal stabilization, recycled and waste product and electrokinetic stabilization techniques). The electrokinetic stabilization is one of the known and valuable method to be applied to soft soil to overcome the drawback and to enhance the properties of peat soil. The in-situ and ex-situ electrokinetic stabilization studies and some other applications inspire researchers in the understanding of EK phenomena to improve its properties. The improvement of the EKS method may depend on various factors such as-as excavation stability, slope stability, unstable embankments, backfill strengthening, soil drainage, remediation of salt-affected soils, dewatering of sludge, mineral extraction, assisting pile driving, groundwater lowering, treatment of dispersive soils, mineral extraction and stabilization of low permeable soil (Razali *et al.*, 2013).

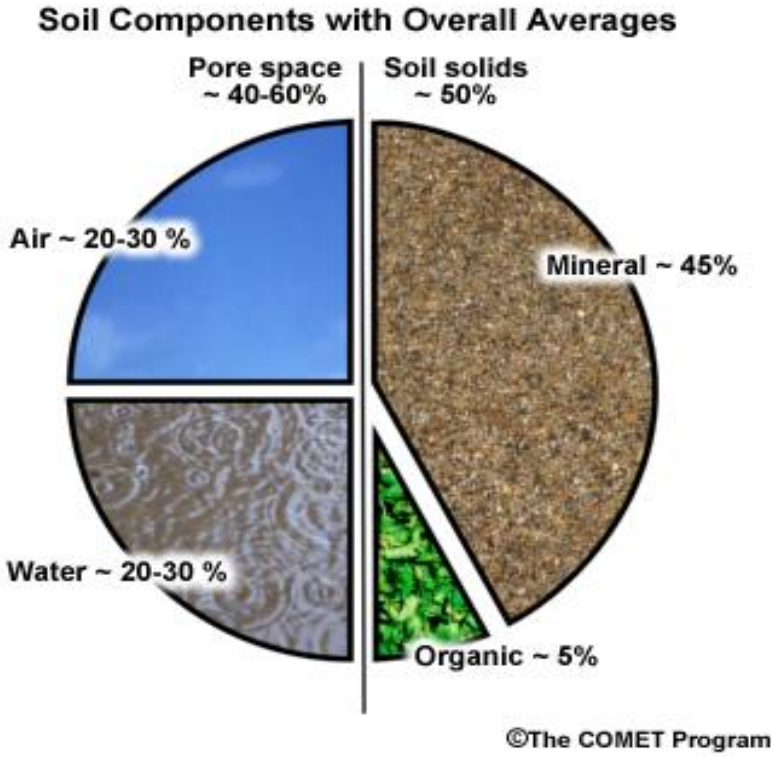

Figure 1.1: Soil component in detail (Bell & Culshaw, 2001).

1.2 Problem statement

Peat soil is known as one of the most problematic soil for construction projects due to its weak properties. Once the moderate load is subject to peat, it consequently causes instability problems (i.e. excessive settlement, local sinking and long-term settlement). There are some significant features associated with peat, which creates some serious problems during or after construction for the soil and making it unfeasible for any earth's constructions.

In West Malaysia, generally, peat is found in the coastal areas, especially in the west parts, i.e. Pontian, Batu Pahat, Kuantan, Pekan districts Pahang, West Selangor and Perak state. Major economic activities and social developments focus on the coastal area which contains problematic soil in Malaysia. The roads construction and coastal high-rise buildings are facing instability problems which foundations are frequently supported by grounds having with low shear strength, high water content and high compressibility. Figure 1.2 (a) shows depression has been occurred due to

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